



Ministry
of
Transportation

MI-134

**DETERMINATION OF
CRUSHED PARTICLES
FOR TEST METHOD
LS - 607**

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

MI-134

DETERMINATION OF CRUSHED PARTICLES
FOR TEST METHOD LS-607

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1. INTRODUCTION

The 1987 and 1988 MTO correlation programs for percent crushed particles (LS-607) showed a wide range in results. This test is subjective in nature and the accuracy of the test is dependant largely on operator experience. The purpose of this report is to reduce the subjectivity of the test and hence the variability of test results by providing descriptions and photographs of crushed and uncrushed particles.

The percent crushed test, LS-607, is used to determine visually the percentage by mass of crushed particles in a processed coarse aggregate. The presence of fractured particles with sharp edges and rough surfaces result in greater stability in a base course or bituminous mix. Crushed particles increase stability due to the interlocking effect of the angular particles and by friction between particles. Smooth, rounded particles have the opposite effect and reduce stability.

Particles can be fractured by various ways, e.g. fracturing during transportation by glacio/fluviol processes prior to deposition in the gravel deposit, processing through a crusher, and handling and transporting of aggregate to stock piles and project sites.

Particles that have been crushed can become, by the definition uncrushed, by some of the above methods, e.g. glacial deposition, agitation on screens, and handling and transporting to stock piles and project sites.

2. DEFINITION OF CRUSHED PARTICLES

A crushed particle is defined as a piece of coarse aggregate which has at least one well-defined face resulting from fracture (figures 1, 2, 3). Particles with smooth faces and rounded edges (fig. 6), or with only small chips removed (fig. 5) are not considered crushed.

GUIDELINES:

1. A well-defined face is one in which the area of the crushed face is at least about 1/5 or 20 per cent of the total surface area. The face is surrounded by edges which are sharp (fig. 1, 2) or slightly rounded (fig. 3).
2. If the well-defined face is less than 1/5 or 20 per cent of the total surface area, it is only a chip and the particle is considered uncrushed (fig. 5).
3. If the particle has both smooth faces and rounded edges (fig. 6) it is considered uncrushed.
4. If the particle has no well-defined face (particle is round and smooth) it is uncrushed (fig. 7).

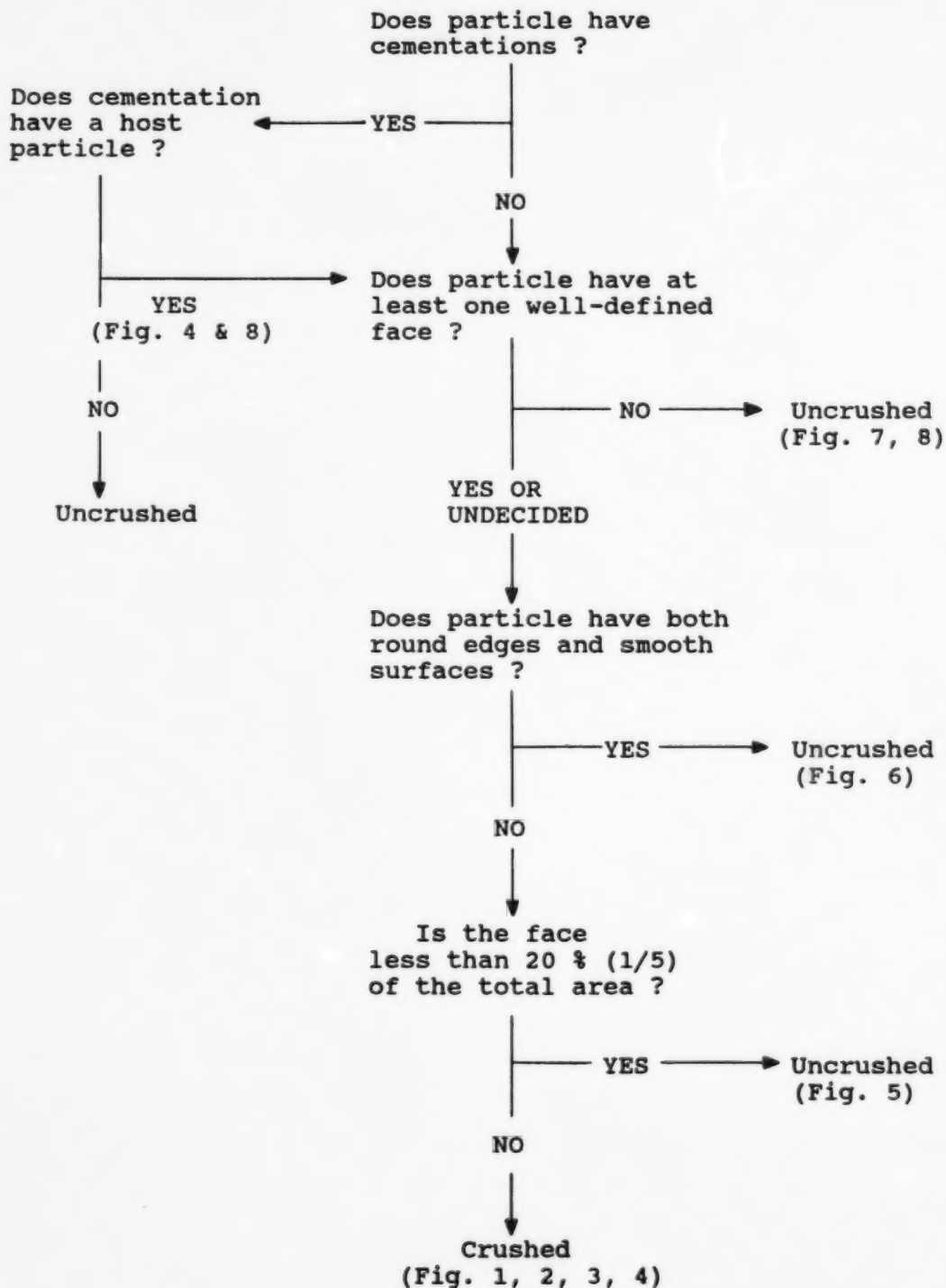
3. QUALITY ASSURANCE

Percent crushed limits are specified for granular and hot mix aggregates. Failure of a material to meet the percent crushed requirements means it will receive a price reduction or be removed from the work completely. When a sample is judged to be borderline or unacceptable by field laboratories, consultation with Regional Quality Assurance and the Regional Laboratory, if necessary, should take place before the decision is finalized.

4. ACKNOWLEDGEMENTS

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APPENDIX 1 - PERCENT CRUSHED DECISIONING FLOW CHART



APPENDIX 2 - PHOTOGRAPHS - FIGURES 1 TO 8

CRUSHED PARTICLES

- Fig. 1 - Particles have at least one well-defined face. The faces are rough with sharp edges.
- Fig. 2 - Particles have at least one well-defined face. The faces are smooth with sharp edges.
- Fig. 3 - These particles are borderline crushed. They have at least one well-defined face. The edges are slightly worn or rounded and the faces are rough.
- Fig. 4 - These are crushed particles because the host stones have at least one well-defined face. They also have numerous smaller particles cemented to them and are therefore called crushed cementations.
- NOTE: These particles are identified as crushed and as cementations.

UNCRUNSHED PARTICLES

- Fig. 5 - The well-defined, crushed faces on all these particles are less than 1/5 or 20 per cent of the total surface area. They are therefore considered as chipped or uncrushed.
- Fig. 6 - These particles have been crushed, but by some form of subsequent abrasion or weathering have become smooth. They do not have well-defined faces. The edges have become rounded. They are borderline uncrushed.
- Fig. 7 - These particles have no well-defined faces. They are round with no obvious edges.
- Fig. 8 - These particles are uncrushed because the host stones have no well-defined faces. They have numerous smaller particles cemented to them, and are therefore called uncrushed cementations.
- NOTE: These particles are identified as uncrushed and as cementations.

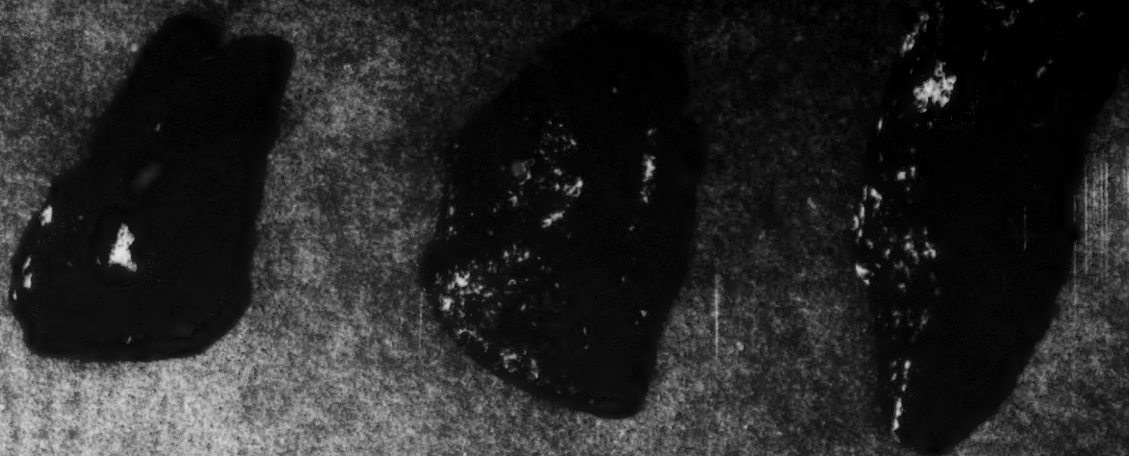


FIG. 1

CRUSHED

(SHARP EDGES, ROUGH SURFACES)

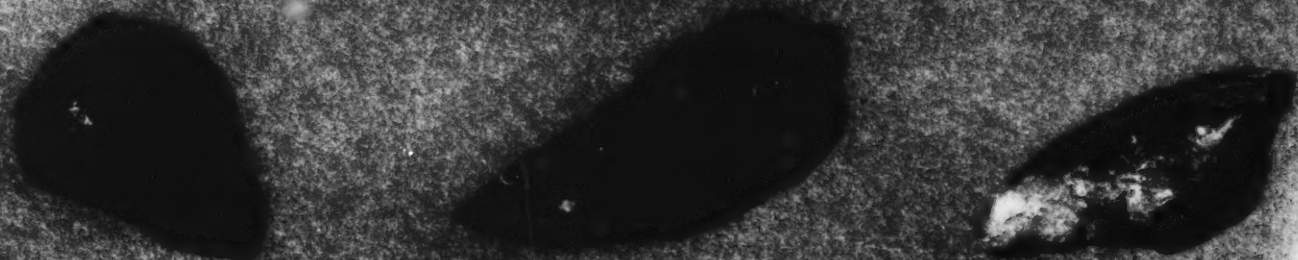


FIG. 2

CRUSHED

(SHARP EDGES, SMOOTH SURFACES)

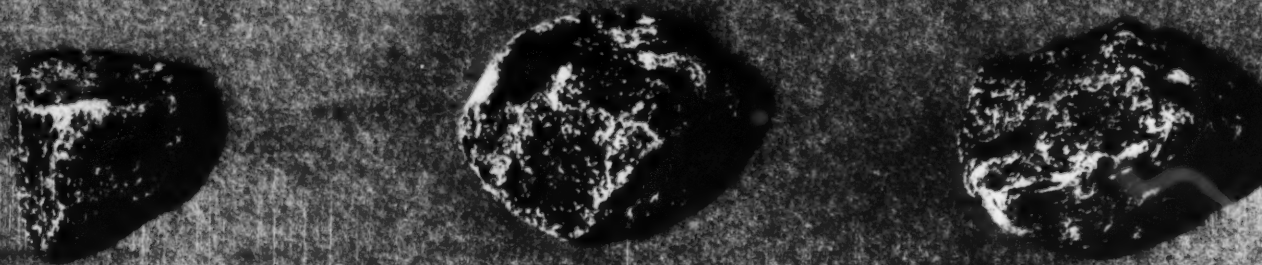


FIG. 3

CRUSHED

(ROUND EDGES, ROUGH SURFACES)

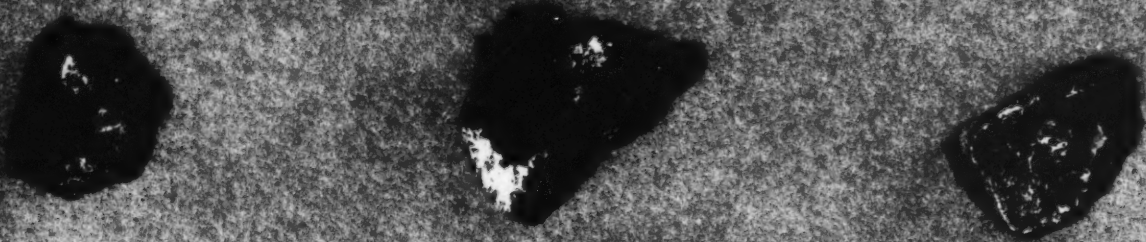


FIG. 4

**CRUSHED
CEMENTATIONS**

FIG. 5

UNCRUSHED

(CHIPPED ONLY)

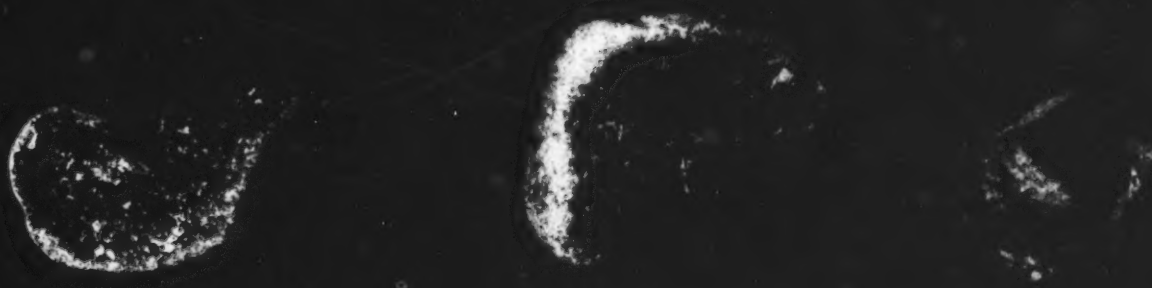


FIG. 6

UNCRUSHED

(ROUND EDGES, SMOOTH SURFACES)



FIG. 7

UNCRUSHED
(ROUNDED PARTICLES, SMOOTH SURFACES)

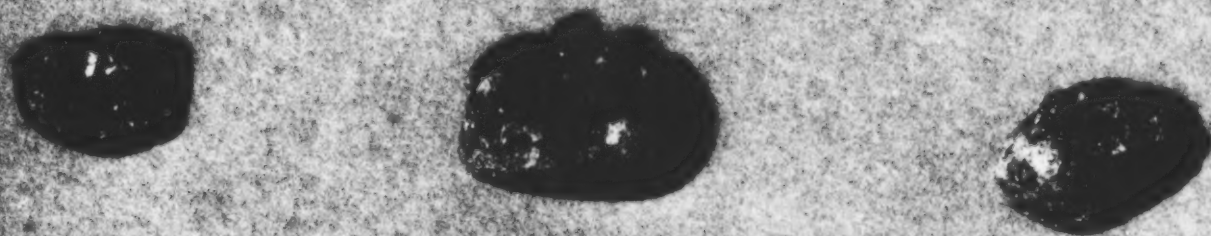


FIG. 8

UNCRUSHED
CEMENTATIONS

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APPENDIX 3 - METHOD OF TEST FOR
DETERMINATION OF PERCENT CRUSHED PARTICLES
IN PROCESSED COARSE AGGREGATE

1. SCOPE

- 1.1 This method covers the visual determination of the percent, by mass, of crushed particles in a processed coarse aggregates.
- 1.2 In conjunction, this method may cover the visual determination of the percent by mass of cementations in a coarse aggregate.

2. RELEVANT DOCUMENTS

- 2.1 MI-134, DETERMINATION OF CRUSHED PARTICLES FOR TEST METHOD LS-607

3. DEFINITION

- 3.1 A CRUSHED PARTICLE is defined as a piece of coarse aggregate which has at least one well-defined face resulting from fracture. Particles with smooth faces and rounded edges, or with only small chips removed, are not considered crushed.
- 3.2 A CEMENTATION is defined as a group of particles of aggregate cemented together which may or may not include a host (dominant) particle.

4. APPARATUS

- 4.1 BALANCE: Of sufficient capacity and sensitive to 1 g or less.

5. PREPARATION OF TEST SAMPLE

- 5.1 Prepare the coarse aggregate in accordance with the Method for Preparation of Coarse Aggregate, MTO Method LS-600.
- 5.2 The test sample shall be prepared from coarse aggregate fractions representing at least 5 per cent or more of the submitted sample.

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- 5.3 The test sample shall be representative of the original sample gradation. In cases where the test sample contains greater individual-sized amounts of material than shown in TABLE 1, individual fractions shall be prepared.

TABLE 1

COARSE AGGREGATE FRACTION		APPROX. MASS, g
PASS	RETAINED	
26.5 mm (1.06 in.)	4.75 mm (No. 4)	1000
13.2 mm (.530 in.)	9.5 mm (3/8 in.)	500
9.5 mm (3/8 in.)	6.7 mm (No. 3)	200
6.7 mm (No. 3)	4.75 mm (No. 4)	75

6. TEST PROCEDURE

- 6.1 Spread the test sample or fraction on a clean, flat surface large enough to permit the particles to be visually inspected.
- 6.2 Separate the particles into crushed and uncrushed portions. If cementations are present, they are separated according to whether the host particle is crushed or uncrushed; if no host particle is present, they are considered as uncrushed cementations.
- 6.3 Weigh each crushed, uncrushed and cementation portion of the sample or fraction to the nearest 1 g.

7. CALCULATION

- 7.1 Calculate the percent of crushed particles in test sample or fraction (to one decimal place), using the following formula:

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$$\% \text{ crushed particles} = \frac{A+B}{A+B+C+D} \times 100$$

where A = mass of crushed particles
 B = mass of crushed cementations
 C = mass of uncrushed particles
 D = mass of uncrushed cementations

- 7.2 When the test is performed on several test fractions or where the as-received sample contains less than 5 per cent on any size, a weighted average value shall be calculated as follows:

Multiply the percentage (based on the as-received coarse aggregate sample portion) on each fraction by the percent crushed particles for that fraction. The sum of those products divided by 100 is the weighted average percentage for the as-received sample.

- 7.2.1. For the purpose of calculating the weighted average consider any sizes (not tested) that contain less than 5 per cent of the as-received sample to have the same value as the average of the next smaller and the next larger size or if one of these sizes is missing, to have the same value as the next larger or smaller size, whichever is present.

- 7.3 If the amount of cemented particles is required, use the following formula:

$$\% \text{ cemented particles} = \frac{B+D}{A+B+C+D} \times 100$$

Then calculate the weighted average value.

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8. REPORTING OF RESULTS

- 8.1 Report the weighted average test result to the nearest whole per cent.
- 8.2 Note any irregularities such as cementations, etc.

9. GENERAL NOTES

- 9.1 If dirt or dust film makes it difficult to determine that the particles have well-defined fractured faces, it is permissible to wash the particles. However, the sample should be dried before weighing.
- 9.2 If a cursory inspection of the sample reveals that there is obviously more than 80 per cent crushed particles, then the sample may be reported as 80 per cent plus, thus eliminating unnecessary testing. One exception to this is H.L.1 coarse aggregate produced from gravel deposits which must be tested in full to satisfy the requirement of 100 per cent crushed particles.
- 9.3 Material used in this test may be re-used if insufficient material is available for other required tests.

